

In the Claims

A complete listing of the claims follows immediately hereinafter.

1-24. (canceled)

25. (currently amended) In a system for tracking the position of a boring tool in the ground as the boring tool moves along an underground path which lies within a region, said boring tool including means for transmitting an electromagnetic locating signal having a dipole field and said system including an above ground arrangement for receiving the electromagnetic locating signal for use in establishing the position of the boring tool, a method comprising the steps of:

- a) providing at least two above ground detectors as part of said arrangement each of which is configured for receiving said locating signal;
- b) locating said detectors at initial positions in said region within a dipole range of said electromagnetic locating signal transmitted from the boring tool at a first, start position;
- c) receiving said electromagnetic locating signal using said detectors with said boring tool first at said start position to produce a first set of electromagnetic data;
- d) moving the boring tool to a second position;
- e) receiving said electromagnetic locating signal using said detectors with said boring tool at said second position to produce a second set of electromagnetic data; and
- f) determining absolute positions of the detectors within said region using certain information including said first and second sets of electromagnetic data in a predetermined way.

26. (original) The method according to Claim 25 wherein said detectors include tilt sensors for measuring a tilt orientation of each detector such that the tilt orientation of each detector forms part of said certain information.

27. (original) The method according to Claim 25 wherein said boring tool includes a pitch sensor such that the pitch angle of the boring tool forms part of said certain information.

28. (original) The method according to Claim 25 wherein the electromagnetic locating signal includes a known signal strength which forms part of said certain information.

29. (original) The method according to Claim 25 including the step of measuring a distance between the first and second positions of the boring tool and, thereafter, using said distance as part of said certain information in a way which improves accuracy in determining the absolute positions of the detectors in said region.

30. (original) The method according to Claim 25 wherein said distance is used in a way which overdetermines the absolute receiver positions so as to permit the use of a least square error technique.

31. (original) The method according to Claim 25 wherein said step of receiving said electromagnetic locating signal in said predetermined way further includes the step of producing one or more additional subsets of said electromagnetic data at one or more additional positions of said boring tool, said additional subsets of electromagnetic

data, thereafter, being used in determining the absolute positions of the detectors as part of the overall electromagnetic data.

32. (original) The method according to Claim 31 wherein the determination of the absolute positions of said detectors includes an overall certain number of known values and an overall certain number of unknown values and wherein measurements taken at said second position and at each additional position of the boring tool contribute at least one more additional known value to said overall certain number of known values such that the number of overall certain number of known values can be increased relative to the overall number of unknown values.

33. (original) The method according to Claim 32 wherein measurements are taken at a sufficient number of positions such that the overall certain number of known values is equal to or greater than the overall certain number of unknown values so as to use only electromagnetic data in determining the absolute positions of said detectors.

34. (original) The method according to Claim 32 wherein the determination of the absolute positions of said detectors includes the step of using the additional known values in place of at least portions of said certain information.

35. (original) The method according to Claim 34 wherein each detector includes a tilt orientation and wherein the determination of the absolute positions of said detectors includes the step of using the additional known values instead of using measured values of tilt orientation for said detectors such that the tilt values form part of said certain number of unknown values.

36. (original) The method according to Claim 35 wherein said boring tool includes a pitch orientation and wherein the determination of the absolute positions of said detectors includes the step of using the additional known values instead of using a measured value of said pitch such that the pitch orientation forms part of said certain number of unknown values.

37. (original) The method according to Claim 36 wherein said electromagnetic locating signal includes a signal strength and wherein the determination of the absolute positions of said detectors includes the step of using the additional known values instead of using an assumed value of said signal strength such that the signal strength forms part of said certain number of unknown values.

38. (currently amended) The method according to Claim 25 wherein said detectors are able to receive said electromagnetic locating signal within said dipole range of said boring tool and wherein said method further comprises the steps of:

- f) after establishing the absolute positions and orientations of said detectors within said region with the detectors at said initial locations within the region, moving the boring tool to a third position such that both detectors remain within said dipole range of the boring tool;
- g) establishing the absolute position and orientation of the boring tool at said third position within said region using the detectors at their initial positions;
- h) moving said detectors to new positions in said region or providing additional detectors at said new positions within the particular dipole range of said boring tool;
- i) receiving said electromagnetic locating signal using the detectors at the new positions with said boring

tool at said third position to produce a first subsequent set of electromagnetic data;

- j) moving the boring tool to a fourth position;
- k) receiving said electromagnetic locating signal using the detectors at the new positions with said boring tool at said fourth position to produce a second subsequent set of electromagnetic data;
- l) using certain information including said first and second subsequent sets of electromagnetic data in a predetermined way to determine absolute positions of the detectors at the new positions within said region.

39. (currently amended) The method according to Claim 38 wherein the detectors at the new positions are farther from the start position of the boring tool than at their initial locations such that the boring tool is locatable for a distance beyond said particular dipole range from the start position of the boring tool.

40. (original) In a system for tracking the position of a boring tool in the ground as the boring tool moves along an underground path which lies within a region, said boring tool including means for transmitting an electromagnetic locating signal and said system including an above ground arrangement for receiving the electromagnetic locating signal, an improvement comprising the steps of:

- a) providing at least two above ground detectors, each of which is configured for receiving said locating signal;
- b) locating said detectors at initial positions in said region within range of said electromagnetic locating signal transmitted from the boring tool at its initial position;
- c) providing transmitter means forming one part of at least a first one of said detectors for transmitting a relative locating signal to other detectors in a setup mode;
- d) receiving said relative locating signal using a second one of said detectors in said setup mode; and
- e) determining the position of the second detector relative to the first detector based on the received relative locating signal.

41. (original) The improvement according to Claim 40 further comprising the steps of:

- e) receiving said electromagnetic locating signal in a predetermined way using said first and second detectors to produce electromagnetic data; and
- f) establishing initial absolute positions of said detectors and said boring tool within said region using certain information including the electromagnetic data in conjunction with the relative position established between the detectors.

42. (original) The improvement according to Claim 41 wherein said detectors include tilt sensors for measuring the tilt angles of each detector such that the tilt angles of each detector form part of said certain information.

43. (original) The improvement according to Claim 42 further comprising the steps of:

- g) moving one of said detectors to a new, unknown location while the other detector remains in its initial, known position;
- h) transmitting said relative locating signal to establish the new location of the moved detector relative to the other detector so as to also establish the absolute position of the moved detector in said region.

44. (original) The improvement according to Claim 43 wherein the moved detector is at least initially out of range of the electromagnetic locating signal at its new location such that a predetermined amount of additional advance of the boring tool causes the moved detector and the other detector to both be in range of said electromagnetic locating signal.

45. (original) The improvement according to Claim 44 wherein the new location of the moved detector is established in proximity to an anticipated drilling path of the boring tool.

46. (original) The improvement according to Claim 44 wherein the moved detector was out of range of the electromagnetic locating signal, prior to being moved from its initial position, as a result of advance of the boring tool and wherein the moved detector is within range of the electromagnetic locating signal, after being moved, such that the moved detector remains within range of the boring tool over a subsequent advance of the boring tool.

47. (original) The improvement according to Claim 44 wherein sufficient additional advance of the boring tool along said anticipated drilling path causes the other detector to be out of range of the electromagnetic locating signal while the moved detector is in range and wherein said improvement further comprises the steps of:

i) moving the other detector to an advance location farther from said boring tool, but still in proximity to said anticipated drilling path;

j) transmitting said relative locating signal to establish the advance location of the other detector relative to the moved detector so as to also establish the absolute position of the other detector at the advance position in said region such that both detectors are again within range of the boring tool to receive the electromagnetic locating signal over further advance of the boring tool.

48. (original) The improvement according to Claim 41 wherein said step of receiving the electromagnetic locating signal in said predetermined way includes the steps of:

measuring said electromagnetic locating signal using the detectors with the boring tool at its first, initial position to produce a first subset of said electromagnetic data,

moving the boring tool to a second position and determining a distance between the first and second positions,

measuring the electromagnetic locating signal with said boring tool at the second position to produce a second subset of said electromagnetic data, and

wherein said step of determining the initial absolute positions of the detectors and the boring tool within said region includes the steps of

combining the first and second subsets of electromagnetic data to produce the overall electromagnetic data, and

determining the absolute positions of the detectors and the boring tool in said region using the overall electromagnetic data in conjunction with the established relative position between the detectors.

49. (currently amended) The improvement according to Claim 41 wherein said system includes a drill rig having an extendable drill string attached to said boring tool such that movement of the boring tool is accomplished by extending or retracting the drill string and wherein said step of receiving the electromagnetic locating signal in said predetermined way includes the steps of:

measuring said electromagnetic locating signal using the detectors with the boring tool at its first, initial position to produce a first subset of said electromagnetic data,

moving the boring tool to a second position by extending said drill string in a way which establishes and determining a distance between the first and second positions,

measuring the electromagnetic locating signal with said boring tool at the second position to produce a second subset of said electromagnetic data, and

wherein said step of determining the initial absolute positions of the detectors and the boring tool within said region includes the steps of

combining the first and second subsets of electromagnetic data to produce the overall electromagnetic data, and

determining the absolute positions of the detectors and the boring tool in said region using the overall electromagnetic data, along with the established relative position between the detectors and said distance measured established between the first and second positions of the boring tool, in determining the absolute positions of the detectors in said region.

50. (original) The improvement according to Claim 49 wherein said step of receiving said electromagnetic locating signal in said predetermined way further includes the step of producing one or more additional subsets of said electromagnetic data at one or more additional positions of said boring tool, said additional subsets of electromagnetic data, thereafter, being used in said absolute position determining step as part of the overall electromagnetic data in a way which improves accuracy in determining the absolute positions of the detectors and the boring tool in said region.

51-70. (canceled)

Please add new claim 71, as follows:

71. (new) The improvement according to claim 40 including configuring the first one of the detectors to transmit the relative locating signal as a dipole locating signal and configuring said boring tool for transmitting said electromagnetic locating signal having a dipole field.